ABSTRACT

The present invention is directed to the creation of zones of permanently altered refractive index characteristics in glass waveguiding devices, including optical fibers and optical waveguides pre-existed in a glass substrate. Such zones in which the refractive index has been permanently altered are created in glass using a very high intensity laser beam which is produced by focusing the light output from an ultrafast pulsed laser at a predetermined target region in the glass. The preferred laser is a Ti:Sapphire amplified, frequency-doubled Erbium-doped fiber laser system, providing light pulses of approximately 100 femtosecond duration, each with an energy of between about 1 nanojoule and 1 millijoule, and preferably at a pulse repetition rate of between 500 Hz and 1 GHz. The repetition rate is chosen to deliver pulses faster than the thermal diffusion time over the dimensions of the volume element being modified. This latter process is to accumulate heat to the point of liquefying the material in order to increase material compliance to the femtosecond writing process and increase the subsequent thermal barrier to relaxation of the written structural element and thereby increase the lifetime of the device or structural function. One or more zones of permanently altered refractive index characteristics can be formed in a waveguiding device, such as an optical fiber by utilizing a focused, pulsed, laser light source which generates a focal region having an intensity greater than the threshold for inducing permanent refractive index changes in the device. The focal region is aligned with the device and relative movement between the focal region and the device has the effect of sweeping the focal region across the device in a predetermined path. The result is a zone within the device in which the refractive index characteristics of the device have been permanently altered so as to control amplitude, phase, spatial propagation or polarization states of light within the material.

29